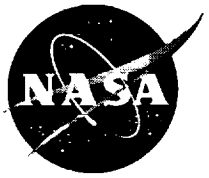
NASA/TM—2000–209891, Vol. 25



Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 25

BOREAS HYD-3 Tree Measurements

J.P. Hardy and R.E. Davis

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.
- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.
- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.
- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at http://www.sti.nasa.gov/STI-homepage.html
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA Access Help Desk at (301) 621-0134
- Telephone the NASA Access Help Desk at (301) 621-0390
- Write to:
  NASA Access Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/TM—2000–209891, Vol. 25

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 25

BOREAS HYD-3 Tree Measurements

Janet P. Hardy and Robert E. Davis
U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
Price Code: A17

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Price Code: A10

BOREAS HYD-3 Tree Measurements

Janet P. Hardy, Robert E. Davis

Summary

The BOREAS HYD-3 team collected several data sets related to the hydrology of forested areas. This data set contains measurements of canopy density (closure), stem density, and DBH from a variety of sites. Canopy density measurements were made during the FFC-W and FFC-T 1994 in both the SSA and the NSA. Stem density measurements were made during FFC-W 1996 in the SSA only. Canopy density measurements were made using a forest densiometer, while measurements of stem density and DBH were made using standard techniques. This study was undertaken to predict spatial distributions of energy transfer, snow properties important to the hydrology, remote sensing signatures, and transmissivity of gases through the snow and their relation to forests in boreal ecosystems. The data are available in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS HYD-03 Tree Measurements

1.2 Data Set Introduction

This data set contains measurements of canopy density (closure), stem density, and diameter at breast height (DBH) from a variety of sites. Canopy density measurements were made during the Focused Field Campaign - Winter (FFC-W) and the Focused Field Campaign - Thaw (FFC-T) 1994 in the BOReas Ecosystem Atmosphere Study (BOREAS) Southern Study Area (SSA) and Northern Study Area (NSA). Stem density measurements were made during FFC-W 1996 in the SSA only. Canopy density measurements were made using a forest densiometer, while measurements of stem density and DBH were made using standard techniques.

1.3 Objective/Purpose

This study was undertaken to predict spatial distributions of energy transfer, snow properties important to the hydrology, remote sensing signatures, and transmissivity of gases through the snow and their relation to forests in boreal ecosystems.

1.4 Summary of Parameters

Parameters measured with respect to this documentation are canopy density (closure), stem density, and DBH.

1.5 Discussion

This study was conducted under the hypothesis that energy transfer and snow water equivalent (SWE) would vary spatially as a function of canopy closure. The goal was to obtain canopy closure data for determining either an average closure of a forest or the closure at a specific location (i.e., over a radiometer). Data were compared with canopy data obtained from aerial photography. Stem density data were used in calibrating a radiative transfer model for predicting incoming solar radiation at the snow surface in forested environments.

1.6 Related Data Sets

BOREAS Forest Cover Data Layers of the NSA-MSA in Raster Format

2. Investigator(s)

2.1 Investigator(s) Name and Title

Robert E. Davis
Research Physical Scientist
U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)

2.2 Title of Investigation

Distributed Energy Transfer Modeling in Snow and Soil for Boreal Ecosystems

2.3 Contact Information

Contact 1:
Janet P. Hardy
U.S. Army CRREL
72 Lyme Road
Hanover, NH 03755-1290
(603) 646-4306
(603) 646-4278 (fax)
jhardy@crrel.usace.army.mil

Contact 2:
Dr. Robert E. Davis
U.S. Army CRREL
72 Lyme Road
Hanover, NH 03775-1290
(603) 646-4219
(603) 646-4278 (fax)
bert@crrel.usace.army.mil

Contact 3:
David Knapp
Raytheon ITSS
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-1424
(301) 286-0239 (fax)
David.Knapp@gsfc.nasa.gov

3. Theory of Measurements

The forest densiometer is used to obtain a quick measurement of overstory density at a point. The instrument consists of a convex mirror with 24 1/4" squares engraved on the surface. The mirror faces up, and the geometry of the overstory above is superimposed on the etched grid on the mirror. Canopy overstory is measured as described below. Stem density is determined by counting the number of stems in a given area. DBH is determined by measuring the circumference of the tree at breast height and converting it to diameter, or by using a tape measure that is precalibrated to DBH based on circumference.

4. Equipment

4.1 Sensor/Instrument Description
Forest densiometer.

4.1.1 Collection Environment
Data were collected during winter conditions.

4.1.2 Source/Platform
Densiometer is hand-held.

4.1.3 Source/Platform Mission Objectives
The measurements of canopy closure and stem density were undertaken primarily to aid in the snow melt modeling effort. Stem density measurements were made at the location of the subcanopy radiation measurement. This information is valuable for calibrating the model used to estimate subcanopy solar irradiance.

4.1.4 Key Variables
Canopy closure, stem density.

4.1.5 Principles of Operation
Canopy Density:

The forest densiometer is used to obtain a quick measurement of overstory density at a point. The instrument consists of a convex mirror with 24 1/4" squares engraved on the surface. The mirror faces up, and the geometry of the overstory above is superimposed on the etched grid on the mirror. Canopy overstory is measured as described in Section 5.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
Densiometer:

Manufacturer: Dr. Paul E. Lemmon
Distributor:
Forestry Suppliers, Inc.
205 West Rankin St.
P.O. Box 8397
Jackson, MS 39284-8397
(800) 647-5368

4.2 Calibration
Not applicable.

4.2.1 Specifications
Not available.

4.2.1.1 Tolerance
Not available.

4.2.2 Frequency of Calibration
Not applicable.

4.2.3 Other Calibration Information
A report by Ganey and Block, 1994 (complete reference given in Section 17.1), compared the densiometer with another technique for measuring canopy density. Although they were unable to determine which technique provided the most accurate measurement, they believe that for point measurements the densiometer is the best available "quick and easy" method. They did conclude, however, that the densiometer can yield different results when used by different observers. This problem was minimized in these data (see Section 10.1).

5. Data Acquisition Methods

Canopy Density:
Once sites were located, the densiometer was used to determine the canopy density at that site. The densiometer was held at waist height and far enough from the observer's body so that his or her head was not visible in the mirror. The instrument was then leveled using the built-in bubble level. For each of the 24 etched squares, the square was divided into quarters and the number of quarter sections covered by canopy (1, 2, 3, or 4) was counted. The total number of quarter sections was recorded (up to 96 possible). Keeping the densiometer in the same location, the observer then rotated 90 degrees and counted again. This process was repeated until the canopy closure sections were counted in all four directions, and the four totals were recorded. The average of the four totals, was then multiplied by 1.04 to determine the canopy closure at that site (see formula in Section 9.1).

Stem Density:
To obtain a measurement of stem density, the area was measured and marked (e.g., 20 m x 25 m), and every stem inside the marked area was counted. The number of stems was divided by the area to get the stem density (see formula in Section 9.1).

DBH:
In the case of the SSA-Old Aspen (OA) site, the DBH of each tree in the marked area was also measured.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Canopy Density: The canopy density measurements were collected at the following approximate locations:

SITE_ID	LONGITUDE	LATITUDE
SSA-OJP-FLXTR-HYD03-CND01	104.69203W	53.91634N
NSA-OJP-FLXTR-HYD03-CND02	98.62028W	55.93011N
NSA-OBS-FLXTR-HYD03-CND02	98.48027W	55.8801N
NSA-YJP-FLXTR-HYD03-CND04	98.29027W	55.90011N
NSA-YJP-FLXTR-HYD03-CND03	98.29027W	55.90011N
NSA-YJP-FLXTR-HYD03-CND01	98.29027W	55.90011N
NSA-OJP-FLXTR-HYD03-CND03	98.62028W	55.93011N
NSA-OBS-FLXTR-HYD03-CND01	98.48027W	55.8801N
NSA-OBS-FLXTR-HYD03-CND03	98.48027W	55.8801N
NSA-YJP-FLXTR-HYD03-CND02	98.29027W	55.90011N
SSA-999-NIB01-HYD03-CND02	104.59484W	53.75285N
SSA-999-NIB01-HYD03-CND03	104.59484W	53.75285N
SSA-9OA-FLXTR-HYD03-CND01	106.19051W	53.63005N
NSA-9BS-HYD3A-HYD03-CND01	97.89026W	55.81011N
NSA-YBS-HYD03-HYD03-CND02	97.87026W	55.83011N
NSA-MIX-HYD03-HYD03-CND03	97.84025W	55.85011N
NSA-9BS-HYD3B-HYD03-CND04	97.82025W	55.87011N
SSA-BSH-110G1-HYD03-CND01	105.81221W	54.52526N
SSA-ASP-110H1-HYD03-CND01	105.8067W	54.50956N
SSA-999-110I1-HYD03-CND01	105.8098W	54.49536N
SSA-BRN-110J1-HYD03-CND01	105.8123W	54.48146N
SSA-ASP-110K1-HYD03-CND01	105.81W	54.46696N
SSA-CLR-110L1-HYD03-CND01	105.8024W	54.43746N
NSA-OJP-FLXTR-HYD03-CND01	98.62028W	55.93011N
SSA-YJP-122D1-HYD03-CND01	104.61914W	53.84426N
SSA-999-122E1-HYD03-CND01	104.61944W	53.84916N
SSA-MIX-122F1-HYD03-CND01	104.62214W	53.85586N
SSA-MIX-122G1-HYD03-CND01	104.60623W	53.89836N
SSA-MIX-HYD03-HYD03-CND0A	104.58044W	53.80006N
SSA-MIX-HYD03-HYD03-CND0T	104.58044W	53.80006N
SSA-MIX-HYD03-HYD03-CND0S	104.58044W	53.80006N
SSA-999-NIB01-HYD03-CND01	104.59484W	53.75285N
SSA-9JP-110A1-HYD03-CND01	105.83864W	54.60117N
SSA-MIX-110B1-HYD03-CND01	105.82606W	54.58848N
SSA-MIX-110C1-HYD03-CND01	105.82461W	54.57386N

SSA-MIX-110D1-HYD03-CND01	105.81851W	54.56146N
SSA-ASP-110E1-HYD03-CND01	105.81461W	54.54696N
SSA-ASP-110F1-HYD03-CND01	105.81301W	54.53426N

The stem density measurements were made near the SSA-Old Black Spruce (OBS) and SSA-OA towers. DBH was also measured at the SSA-OA site.

SITE_ID	LONGITUDE	LATITUDE
SSA-9OA-FLXTR-HYD03-STD01	106.19779	53.62889N
SSA-OBS-FLXTR-HYD03-STD01	105.11779	53.9871N7

7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution

Canopy Density:
The areas over which measurements of canopy density were made range from 25 to 500 square meters.

Stem Density:
At the SSA-OBS and SSA-OA sites, the area covered was approximately 500 square meters.

DBH: The DBH was measured only at the SSA-OA site.

7.1.4 Projection
These data were collected at various points whose coordinates are given in latitude and longitude in the North American Datum of 1983 (NAD83).

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Canopy Density: FFC-W and FFC-T 1994
Stem Density: FFC-W 1996

7.2.2 Temporal Coverage Map

Canopy Density:

Dates	Site
07-FEB-1994	Montreal Lake
08-FEB-1994	SSA-Old Jack Pine (OJP), SSA-Young Jack Pine (YJP)
09-FEB-1994	SSA Highway 106 at Triple Junction
10-FEB-1994	SSA-OA
13-FEB-1994	NSA Gillam Road
14-FEB-1994	NSA-YJP
15-FEB-1994	NSA-OJP
16-FEB-1994	NSA-OBS
24-APR-1994	NSA-OBS
26-APR-1994	NSA-YJP

Stem Density:

Dates	Site
03-MAR-1996	SSA-OBS
08-MAR-1996	SSA-OA

DBH:

Dates	Site
08-MAR-1996	SSA-OA

7.2.3 Temporal Resolution

In most cases, these measurements were taken only one time for each site.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

HYD03_CANOPY_DENSITY

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
COVER_TYPE
NUM_OBS
MEAN_CANOPY_DENSITY
CRTFCN_CODE
REVISION_DATE

HYD03_STEM_DENSITY

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
PLOT_ID
PLOT_AREA
NUM_TREES
CRTFCN_CODE
REVISION_DATE

HYD03_DBH

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
DBH
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

HYD03_CANOPY_DENSITY

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
COVER_TYPE	The dominant species, vegetation or type of land cover that exists at the location.
NUM_OBS	Number of observations of the given sample used to calculate given measurements.
MEAN_CANOPY_DENSITY	The mean canopy density at the site.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

HYD03_STEM_DENSITY

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
PLOT_ID	This is the plot from which the measurement came.
PLOT_AREA	This is the area of the plot from which the measurement was taken.
NUM_TREES	The number of trees that exist in a particular plot.

CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

HYD03_DBH

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
DBH	The diameter at breast height (DBH) of the tree.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

HYD03_CANOPY_DENSITY

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
COVER_TYPE	[none]
NUM_OBS	[counts]
MEAN_CANOPY_DENSITY	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD03_STEM_DENSITY

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
PLOT_ID	[none]
PLOT_AREA	[meters^2]
NUM_TREES	[counts]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD03_DBH

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
DBH	[millimeters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

HYD03_CANOPY_DENSITY

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
COVER_TYPE	[Supplied by Investigator]
NUM_OBS	[Supplied by Investigator]
MEAN_CANOPY_DENSITY	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

HYD03_STEM_DENSITY

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
PLOT_ID	[Supplied by Investigator]
PLOT_AREA	[Supplied by Investigator]
NUM_TREES	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

HYD03_DBH

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
DBH	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files.

HYD03_CANOPY_DENSITY

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-HYD3A	SSA-YJP-122D1	None	None	None	None
SUB_SITE	HYD03-CND01	HYD03-CND0T	None	None	None	None
DATE_OBS	07-FEB-94	26-APR-94	None	None	None	None
COVER_TYPE	N/A	N/A	None	None	None	Blank
NUM_OBS	0	9	None	None	None	None
MEAN_CANOPY_DENSITY	11	92	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	21-JUL-95	21-JUL-95	None	None	None	None

HYD03_STEM_DENSITY

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-9OA-FLXTR	SSA-OBS-FLXTR	None	None	None	None
SUB_SITE	HYD03-STD01	HYD03-STD01	None	None	None	None
DATE_OBS	03-MAR-96	08-MAR-96	None	None	None	None
PLOT_ID	1	9	None	None	None	None
PLOT_AREA	25	500	None	None	None	None
NUM_TREES	12	57	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	17-APR-97	17-APR-97	None	None	None	None

HYD03_DBH

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-9OA-FLXTR	SSA-9OA-FLXTR	None	None	None	None
SUB_SITE	HYD03-DBH01	HYD03-DBH01	None	None	None	None
DATE_OBS	08-MAR-96	08-MAR-96	None	None	None	None
DBH	90	250	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	17-APR-97	17-APR-97	None	None	None	None

```
--------------------------------------------------------------------------------
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
--------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

HYD03_CANOPY_DENSITY

```
SITE_NAME,SUB_SITE,DATE_OBS,COVER_TYPE,NUM_OBS,MEAN_CANOPY_DENSITY,CRTFCN_CODE,
REVISION_DATE
'SSA-999-110I1','HYD03-CND01',07-FEB-94,'-',0,-999,'CPI',21-JUL-95
'SSA-9JP-110A1','HYD03-CND01',07-FEB-94,'Jack Pine',7,91,'CPI',21-JUL-95
```

HYD03_STEM_DENSITY

```
SITE_NAME,SUB_SITE,DATE_OBS,PLOT_ID,PLOT_AREA,NUM_TREES,CRTFCN_CODE,REVISION_DATE
'SSA-OBS-FLXTR','HYD03-STD01',03-MAR-96,'1',25,18,'CPI',17-APR-97
'SSA-OBS-FLXTR','HYD03-STD01',03-MAR-96,'2',25,16,'CPI',17-APR-97
```

HYD03_DBH

```
SITE_NAME,SUB_SITE,DATE_OBS,DBH,CRTFCN_CODE,REVISION_DATE
'SSA-9OA-FLXTR','HYD03-DBH01',08-MAR-96,190,'CPI',17-APR-97
'SSA-9OA-FLXTR','HYD03-DBH01',08-MAR-96,210,'CPI',17-APR-97
```

8. Data Organization

8.1 Data Granularity

The smallest amount of data that can be ordered from this data set is a day's worth of data for a particular site.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

Canopy Closure = Average of four counts x 1.04 = canopy closure (%)
Stem Density = Number of stems in measured area divided by measured area

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

None, other than what is indicated above.

9.2.1 Processing Steps

Use formula above to calculate canopy density.

9.2.2 Processing Changes

Not applicable.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Not applicable.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

Not applicable.

10. Errors

10.1 Sources of Error

Different operators of the densiometer may produce different results, depending on the operator's familiarity with the technique. For this reason, the canopy density data were consistently measured by the same person. The other potential error is in the ability of the operator to hold the densiometer level during a measurement. Ganey and Block (1994) suggest using a tripod to reduce error caused by observer movement. For this study, a tripod was not used in measurements of canopy density.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Aerial photography and forest cover data of the BOREAS NSA, provided by Manitoba Natural Resources of Winnipeg, were used to confirm measured canopy closures. BOREAS Information System (BORIS) staff used the forest cover data set at a scale of 1:15,840, to extract and grid the species cover and crown closure. Image analysis classified the YJP forest in the canopy closure class "31 to 50%", and the OJP and OBS forests both fell in the canopy closure class of "71% and over." Canopy closure measurements using the densiometer compared favorably with those determined from the aerial photo data (NSA, YJP = 42%; NSA, OJP = 86%; and NSA, OBS = 83%).

10.2.2 Confidence Level/Accuracy Judgment

The confidence level and accuracy of the canopy closure measurements is dependent on scale. One measure of canopy closure at a point, with its associated spatial resolution, provides a reliability of about +/-1.3% (Lemmon, 1957). To accurately characterize a forest canopy closure, several measurements with the densiometer should be made to account for the natural variability. The more measurements made, the greater the confidence in the data.

10.2.3 Measurement Error for Parameters

Not available.

10.2.4 Additional Quality Assessments

Not applicable.

10.2.5 Data Verification by Data Center

Data that were loaded into the data tables were spot checked against the original ASCII data that were submitted to check for data loading errors.

11. Notes

11.1 Limitations of the Data

These data were collected in winter. Canopy closure measurements in deciduous forests will be very different when leaves are on the trees.

11.2 Known Problems with the Data

None.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

This data set provides data specific to selected sites for the purpose of calibrating radiative transfer and snow melt models. It may also be used as "ground truth" for comparison with forest cover maps.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

An undetermined spreadsheet software package was used to organize the data.

14.2 Software Access

None given.

15. Data Access

The tree measurement data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/ [Internet Link].

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products
Contact BORIS staff.

16.2 Film Products
None.

16.3 Other Products
These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation
Ganey, J.L. and W.M. Block. 1994. A comparison of two techniques for measuring canopy closure, Western Jour. Appl. Forestry 9(1)21-23.

Lemon, P.E. 1956. A spherical densiometer for estimating forest overstory density. Forest Science, 2(4)314-320.

Lemon, P.E. 1957. A new instrument for measuring forest overstory density. Journal of Forestry, 55(9)667-668.

17.2 Journal Articles and Study Reports
Davis, R.E., C. Woodcock, and J.P. Hardy. 1996. Toward spatially distributed modeling of snow in the boreal forest. Eos Transactions, AGU 1995 Fall Meeting, Abstract, p. 218.

Davis, R.E., J.P. Hardy, W. Ni, C. Woodcock, J.C. McKenzie, R. Jordan, and X. Li. 1997. Variation of snow cover ablation in the boreal forest: A sensitivity study on the effects of conifer canopy. Journal of Geophysical Research. 102(D24):29,389-29,395.

Hardy, J.P., R.E. Davis, and G.C. Winston. 1995. Evolution of factors affecting gas transmissivity of snow in the boreal forest. In: Biogeochemistry of Seasonally Snow-Covered Catchments (ed. by K. Tonnessen, M.W. Williams, and M. Tranter) (Proc. Boulder Symp., July 1995). IAHS publication no. 228, p. 51-60.

Hardy, J.P., R.E. Davis, and R. Jordan. 1996. Snow melt modeling in the boreal forest. Eos Transactions, AGU 1996 Fall Meeting, abstract, p. 196.

Hardy, J.P., R.E. Davis, R. Jordan, X. Li, C. Woodcock, W. Ni, and J.C. McKenzie. 1997. Snow ablation modeling at the stand scale in a boreal jack pine forest. Journal of Geophysical Research. 102(D24): 29,397-29,405.

Hardy, J.P., R.E. Davis, R. Jordan, W. Ni and C. Woodcock, 1998. Snow ablation modelling in a mature aspen stand of the boreal forest. Hydrological Processes, 12 (10/11), p. 1763-1778.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Winston, G.C., B.B. Stephens, E.T. Sundquist, J.P. Hardy, and R.E. Davis. 1995. Seasonal variability in gas transport through snow in a boreal forest. In: Biogeochemistry of Seasonally Snow-Covered Catchments (ed. by K. Tonnessen, M.W. Williams, and M. Tranter) (Proc. Boulder Symp., July 1995). IAHS publication no. 228, p. 61-70.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
BS - Black Spruce
CD-ROM - Compact Disk-Read-Only Memory
CGR - Certified by Group
CPI - Checked by Principal Investigator
CPI-??? - CPI but questionable
CRREL - Cold Regions Research and Engineering Laboratory
DAAC - Distributed Active Archive Center
DBH - Diameter at Breast Height
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
FFC-T - Focused Field Campaign - Thaw
FFC-W - Focused Field Campaign - Winter
GIS - Geographic Information System
GMT - Greenwich Mean Time
GSFC - Goddard Space Flight Center
HTML - Hyper-Text Markup Language
HYD - Hydrology
NAD83 - North American Datum of 1983
NASA - National Aeronautics and Space Administration
NSA - Northern Study Area
OA - Old Aspen
OBS - Old Black Spruce
OJP - Old Jack Pine
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
PRE - Preliminary
SSA - Southern Study Area
URL - Uniform Resource Locator
YBS - Young Black Spruce
YJP - Young Jack Pine

20. Document Information

20.1 Document Revision Date

Written: 23-Apr-1997
Revised: 06-May-1999

20.2 Document Review Date(s)

BORIS Review: 12-Mar-1998
Science Review: 15-Jul-1997

20.3 Document ID

20.4 Citation

When using these data, please include the following acknowledgment and cite the following papers:

The BOREAS HYD-03 subcanopy meteorological data were collected and processed by Janet P. Hardy and Robert E. Davis of US Army CRREL. Their efforts in making these data available are greatly appreciated.

Davis, R.E., J. P. Hardy, W. Ni, C. Woodcock, C.J. McKenzie, R. Jordan and X. Li, 1997. Variation of snow cover ablation in the boreal forest: A sensitivity study on the effects of conifer canopy. J. of Geophys. Res., 102 (N24), 29,389-29,396, December 26, 1997.

Hardy, J.P., R.E. Davis, R. Jordan, W. Ni and C. Woodcock, 1998. Snow ablation modelling in a mature aspen stand of the boreal forest. Hydrological Processes, 12 (10/11), p. 1763-1778.

Hardy, J.P., R.E. Davis, R. Jordan, X. Li, C. Woodcock, W. Ni and J.C. McKenzie, 1997. Snow ablation modeling at the stand scale in a boreal jack pine forest. , J. of Geophys. Res., 102 (N24), 29,397-29,406, December 26, 1997 .

If using data from the BOREAS CD-ROM series, also reference the data as:

Davis, R.E., "Distributed Energy Transfer Modeling in Snow and Soil for Boreal Ecosystems." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 2000	Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS HYD-3 Tree Measurements

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
Janet P. Hardy and Robert E. Davis
Forrest G. Hall and David E. Knapp, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 25

11. SUPPLEMENTARY NOTES
J.P. Hardy and R.E. Davis: U.S. Army Cold Regions Research and Engineering Laboratory (CRREL);
D.E. Knapp: Raytheon ITSS

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The BOREAS HYD-3 team collected several data sets related to the hydrology of forested areas. This data set contains measurements of canopy density (closure), stem density, and DBH from a variety of sites. Canopy density measurements were made during the FFC-W and FFC-T 1994 in both the SSA and the NSA. Stem density measurements were made during FFC-W 1996 in the SSA only. Canopy density measurements were made using a forest densiometer, while measurements of stem density and DBH were made using standard techniques. This study was undertaken to predict spatial distributions of energy transfer, snow properties important to the hydrology, remote sensing signatures, and transmissivity of gases through the snow and their relation to forests in boreal ecosystems. The data are available in tabular ASCII files.

14. SUBJECT TERMS	15. NUMBER OF PAGES
BOREAS, hydrology, remote sensing signatures, transmissivity of gases.	19
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL